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ESTIMATION OF RADON LEVELS IN GROUNDWATER SAMPLES FROM GRADUATE'S VILLAGES IN WEST NILE DELTA, EGYPT USING ALPHA TRACK DETECTORS

A. A. EMBABY[1], HESHAM A. YOUSEF[2] & H. A. LAKEN[3]

[1]*Geology Department, Faculty of Science, Damietta University, Damietta, Egypt*

[2]*Physics Department, Faculty of Science, Suez University, Suez, Egypt*

[3]*Physics Department, Faculty of Science, Mansoura University, Mansoura, Egypt*

ABSTRACT

It is important to measure radon gas in the surrounding environment to assess the change in radioactivity background levels. Groundwater is the main source for domestic and agricultural uses in the most reclaimed areas in the western Nile Delta. In the present study radon concentration and exhalation rate were measured in groundwater samples using passive technique with the CR-39 detector. The samples were collected from nineteen locations of the Graduate's Villages at western Nile Delta, Egypt. The values of radon concentration ranged from 1.18 ± 0.09 to 6.17 ± 0.23 Bql^{-1} and the surface exhalation rate ranged from 0.08 to 0.45 Bqm^{-2} h^{-1}. From the obtained results we can conclude that the values of radon concentration are lower than the recommended limit of UNSCEAR and EPA.

KEYWORDS: Radon, Exhalation Rate, Groundwater, CR-39, Passive Technique.

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Original Article

INTRODUCTION

Radon is a naturally occurring radioactive gas that may be found in drinking water and indoor air. Radon gas decays into radioactive particles that can get trapped in your lungs when you breathe it and cause lung cancer [1]. Radon is a noble gas formed from the decay of uranium or radium. It escapes from the earth's crust through cracks and crevices in bedrock and either dissolves in groundwater [2]. Radon is soluble in water and dissolved radon can be transported in water some distance from where it originated. Ingested radon dissolved in drinking water is also a health risk, because it may cause a stomach cancer. The risk caused by drinking water containing dissolved radon is extremely much lower than inhaling radon [3]. The most radionuclides are minerals dissolved in water and radioactive minerals occur irregularly in the bedrock, similar to other minerals and they dissolve easily in water. The natural radioactivity results from water passing through deposits of naturally occurring radioactive materials. In some areas this causes the groundwater to exceed current or proposed public drinking water standards for radioactivity [4]. Radon is soluble in water and this rate of exposure may also be important if high concentrations are found in drinking water [5]. The analysis of drinking and groundwater shows that the natural radioactivity in water varies over a wide range, mainly depending on the geological characteristics of the soil [6]. Water is very important to life of human, animal and plants. Groundwater is an important water resource for domestic and agriculture needs for reclaiming the desert. Radon concentration measurements were carried out in different water samples from different areas in the world using alpha track detectors with passive technique. Groundwater is an important source of water supply in Egypt, Nile water alone is no longer sufficient for the

increasing water requirements for different development activities.

Hydrogeological Situation

The groundwater west Nile Delta area is available from several water-bearing formations belonging to Quaternary (Recent and Pleistocene), Neogene (Pliocene and Miocene) and Oligocene [7]. The present study focused on the Pleistocene aquifer, which represents the main aquifer in the groundwater system west of the Nile Delta. The Pleistocene deposits are made up of Nile sands and gravels with thin clay intercalation, also they are hydraulically interbreed with the surface water systems (irrigation canals, drains, and lakes) cutting through the surface [8]. Recharge and discharge of the aquifer appeared to become much more variable depends on the changes in the land use west of the Nile Delta. Recharge to the aquifer takes place through; infiltration of rainfall water, infiltration and downward leakage of excess surface irrigation water and leakage from canals and inter-aquifer flow of groundwater. The main discharge takes place through; outflow into the drainage system, direct extraction from a large number of production wells, and evapotranspiration and inter-aquifer flow of groundwater [9]. The groundwater exists mostly under free water table conditions and partially under semi-confined conditions. Its depth is very close to the ground surface and increases towards the southwest of the study area.

Location of the Studied Area

Radon was measured in Graduate's Villages west Nile Delta fringe that is bounded by Rosetta Branch of the River Nile from the east, El-Nubariya Canal and El-Nasr Canal from the north of Sadat City and Wadi El-Natrun from the south and southwest. Also occupies the area between Cairo at the equator and Alexandria, west of Rosetta branch, and extends westward to the desert area from the west of Wadi el-Natrun [10]. The area is crossed by a very important two road, Cairo-Alexandria Desert road. The studied area is limited by latitudes (30^o 47' 12.8" and 30^o 38' 8.89") and longitudes (30^o 46' 37.6" and 30^o 05' 36.3") as shown in Figure 1.

The present study aimed to determine radon concentration and surface exhalation rate in different groundwater samples collected from Graduate's Villages western Nile Delta, Egypt. This work attempts to understand the occurrence and distribution of radon in the water samples for the studied area in order to use as reference information of the radioactivity background in the surrounding environment.

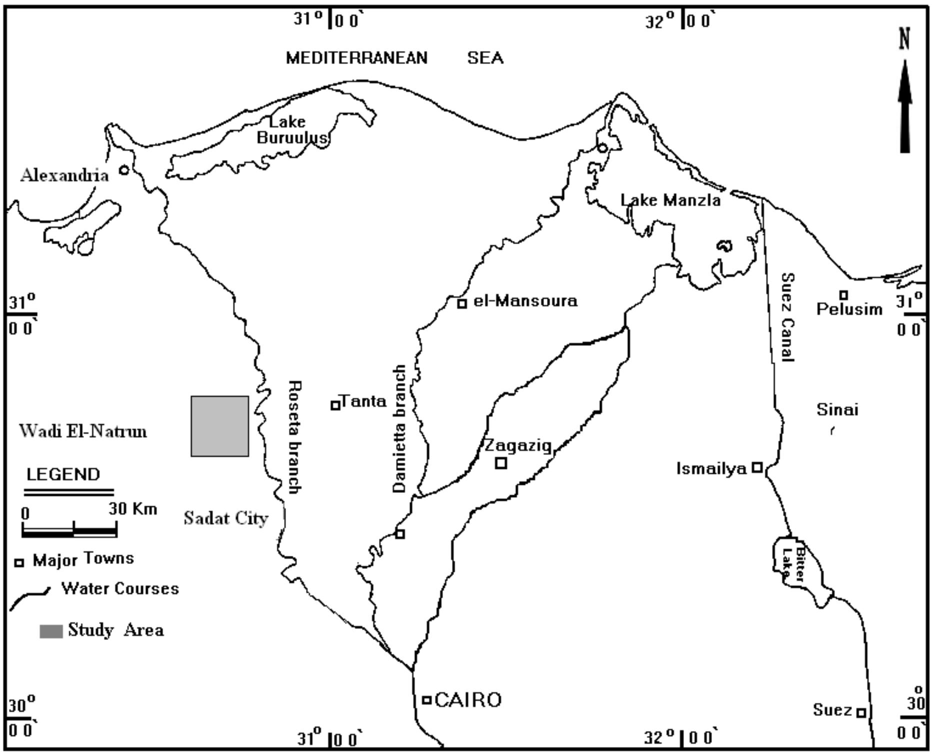

Figure 1: The Location Map of the Graduate's Villages, West Nile Delta, Egypt

MATERIALS AND METHODS

Nineteen samples were collected from 15 villages of Graduate's Villages at western Nile Delta, Egypt. The total of groundwater wells varying in depth from 14 to 135 m have been examined and sampled to carry out the physical-chemical parameters of the groundwater. The samples were collected from shallow tube wells and wells tapping the quaternary sand aquifer. The parameters such as pH, and total dissolved solids (TDS) were measured in the field using a pH meter (CONSORT P903). The water samples were directly obtained from groundwater and collected in polyethylene bottles (6 litters). After this HCl with concentration 10 ml/l has been added to the bottle to prevent microorganisms and prevent absorption radionuclides by the plastic containers. Before use the containers were washed with dilute hydrochloric acid and rinsed with distilled water. The water samples were concentrated by means of active coal absorption and evaporated. The values of radon concentration and exhalation rate were measured using passive technique (Can Technique) with the CR-39 detectors. The samples were carefully sealed for 60 days in cylindrical containers made from a good kind of plastic with dimensions of 9.40 cm in diameter and 16 cm in high. Each sample container was capped tightly to an inverted cylindrical plastic cover as shown in Figure 2. A piece of CR-39 of 700 µm thickness detector of area 1.5 cm x 1.5 cm fixed at the bottom center of the inverted plastic cover [11].

After the irradiation period the detectors were collected and chemically etched in NaOH solution 6.25N at 70 ±1°C for 7 hours [12, 13]. After etching the CR-39 detectors were washed in distilled water and then dipped for a few minutes in a 5 % acetic acid solution and washed again with distilled water and finally air dried. The track density was determined using an optical microscope [12] which calibrated before usages, with magnification of 640. The background of the CR-39 detector was counted using an optical microscope and subtracted from the count of all detectors. The value of radon concentration in (Bqm^{-3}) at secular equilibrium is given by the following equation:

$$C_{Rn} = \frac{\rho}{\eta T} \tag{1}$$

Where, C_{Rn} is radon concentration (Bqm^{-3}) in air, ρ is the track density (track cm^{-2}), T is the exposure time (day), and η is the calibration coefficient of CR-39 nuclear track detectors (tracks $cm^{-2}day^{-1}/Bqm^{-3}$) of radon [14]. Radon concentration in water samples (C_w) was calculated using the following equation:

$$C_W = C_{Rn} \frac{\lambda h T}{L} \tag{2}$$

Where C_w is radon concentration in water samples (Bql^{-1}), C_{air} is a radon concentration in air (Bql^{-1}), λ is the decay constant of radon gas (0.1814 day^{-1}), h is a high of detector from the surface of the water (cm), T is the irradiation time of the detectors (day), L is height of the water inside the Can (cm) [15].

Radon exhalation rate is given by the relation**:**

$$E_A = \frac{CV\lambda}{A[T+\frac{1}{\lambda}(e^{-\lambda T}-1)]} \tag{3}$$

Where, E_A is the surface exhalation rate in ($Bqm^{-2}h^{-1}$), C is the integrated radon exposure , λ is the decay constant of radon (h^{-1}), V is the effective volume of the cup (m^3), A is the area covered by the can (m^2) and T is the irradiation time [16, 17].

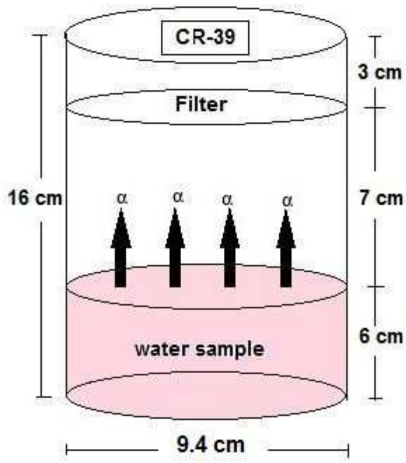

Figure 2: Schematic Diagram of the Cylindrical Container of the Sample

RESULTS AND DISCUSSIONS

The values of radon concentration in groundwater and surface exhalation rate were given by Table 1. The values of radon concentration varied from 1.18 ± 0.09 to 6.17 ± 0.23 Bql^{-1}. From this we find that the high value of radon concentration found in Mohamed Refaat village and the lowest value in Taha Hussein village. Also the values of surface exhalation rate ranged from 0.08 to 0.45 $Bqm^{-2}\ h^{-1}$.

These estimated are depending on the geographical region, which relating to temperature dissolved inorganic salts and geological composition. TDS content of mineral water samples ranged from 600 to 2120 mgl^{-1}. The values of pH were measured and the depth of the wells and it were ranged from 7.22 to 8.32, but the total depth of the wells ranged from

14-135 m, respectively. Figure 3 shows the comparison between the values of radon concentration of the measured samples. From the figures, sample number 12 has a high value but sample number 2 has a lower value. The comparison between the values of surface exhalation rate is given by Figure 4. From figures we find that the higher values found in Mohamed Refaat village and the lowest value in Taha Hussein village. The correlation relation (linearity) between radon concentration and surface exhalation rate of the samples is equal ($R^2 \approx 0.98$) as shown in Figure 5. This is a good correlation has been observed between the results of water samples. The correlation coefficient is linear because the values of exhalation rate depend on radon concentration since the volume of the cup, the area of the sample and decay constant of radon are the same for all samples. A positive correlation has been observed between radon concentration and the exhalation rate of groundwater samples. The radon exhalation study is important for understanding the relative contribution of the material to the total radon concentration found in the water samples and helpful to study radon health hazard.

The correlation relation between depth and radon concentration was given by Figure 6. This correlation has been observed between the depth of wells and radon concentration of water samples and its equal ($R^2= 0.80$). This means that the values of radon concentration are affected by depth. The correlation relation between radon concentration and the pH number given by Figure 7 and the correlation coefficient ≈ 0.32 is poor correlation, this means that the values of radon concentration not affected by changing in pH number. Also the correlation relation between total dissolved solids (TDS) and radon concentration as shown in Figure 8. The relationship between radon concentrations and TDS is not directly linear. This means that there is no correlation between the values of radon concentration and total dissolved solid in the water samples. Water with a higher TDS may have water quality problems and be unpleasant to drink.

Table 1: The Values of Radon Concentration, Surface Exhalation Rate, Ph, TDS and Depth of Water Samples

No.	Village	Depth (m)	pH	TDS (mg l^{-1})	C_{Rn} (Bql^{-1})	E_A ($Bqm^{-2}h^{-1}$)
1	Abd Adeem Abul Ataa	30	7.51	620	2.36 ± 0.14	0.17 ± 0.04
2	Taha Hussein	14	7.08	930	1.18 ± 0.09	0.08 ± 0.02
3	Abu Bakir El Sideeq	135	8.32	925	4.92 ± 0.21	0.36 ± 0.06
4	Ahmed Shawqi	130	7.75	760	4.90 ± 0.21	0.35 ± 0.06
5	Jeneklees	120	7.82	740	4.30 ± 0.19	0.31 ± 0.05
6	19 Luhoom	80	7.50	600	1.49 ± 0.10	0.10 ± 0.03
7	Tawfeeq El Hakeem	80	7.93	680	3.59 ± 0.18	0.26 ± 0.05
8	El Shaeshaee	__	8.16	785	5.75 ± 0.23	0.42 ± 0.06
9	Ali Ebn Abi Talib	__	7.62	802	1.52 ± 0.11	0.11 ± 0.03
10	Najeeb Mahfooz	25	7.78	1472	1.92 ± 0.12	0.14 ± 0.03
11	Abd El-Muneem Reyad	42	7.78	805	1.61 ± 0.10	0.11 ± 0.03
12	Mohamed Refaat	_	7.88	2120	6.17 ± 0.23	0.45 ± 0.06
13		30	7.90	1350	2.14 ± 0.12	0.15 ± 0.03
14		36	7.55	928	1.52 ± 0.10	0.11 ± 0.03
15	Village 107	50	7.58	1414	2.58 ± 0.14	0.18 ± 0.04
16		40	7.22	1171	1.89 ± 0.12	0.13 ± 0.03
17	Imam Hussein	60	7.57	1460	2.96 ± 0.16	0.21 ± 0.04
18	El Gazaalee	18	7.60	858	1.47 ± 0.10	0.10 ± 0.03
19		40	8.17	715	1.54 ± 0.10	0.11 ± 0.03

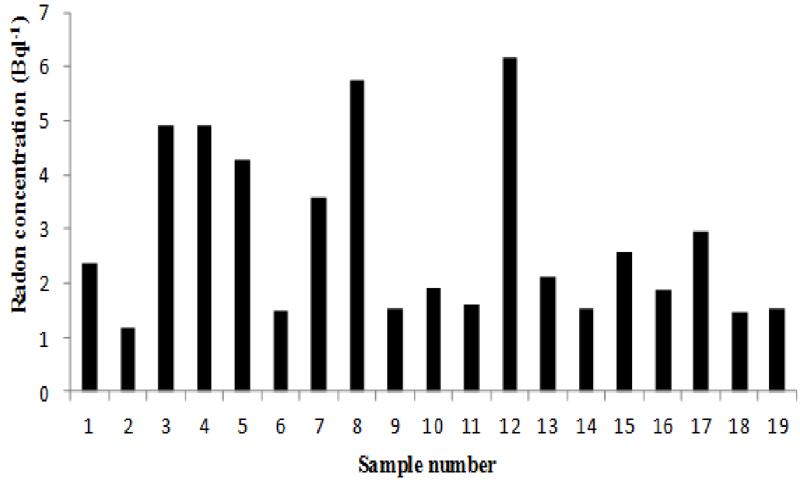

Figure 3: The Relation between Sample Number and Radon Concentration

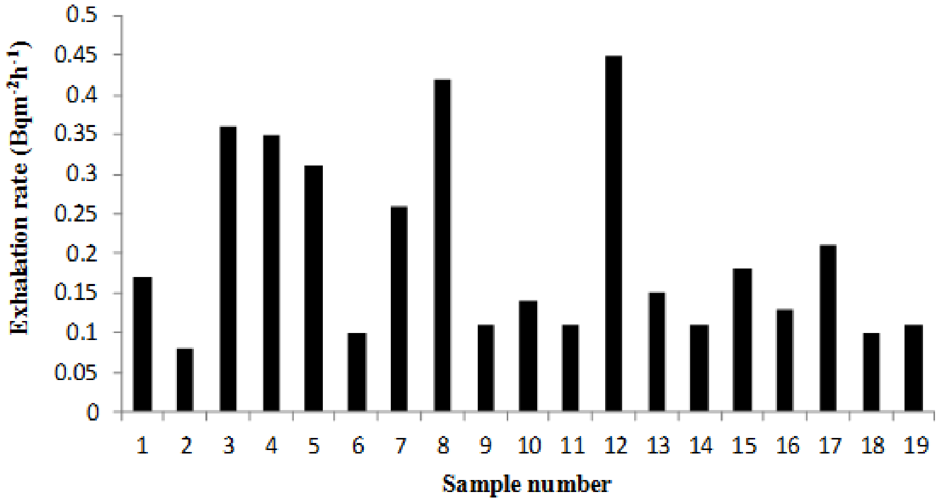

Figure 4: The Relation between Sample Number and Radon Exhalation Rate

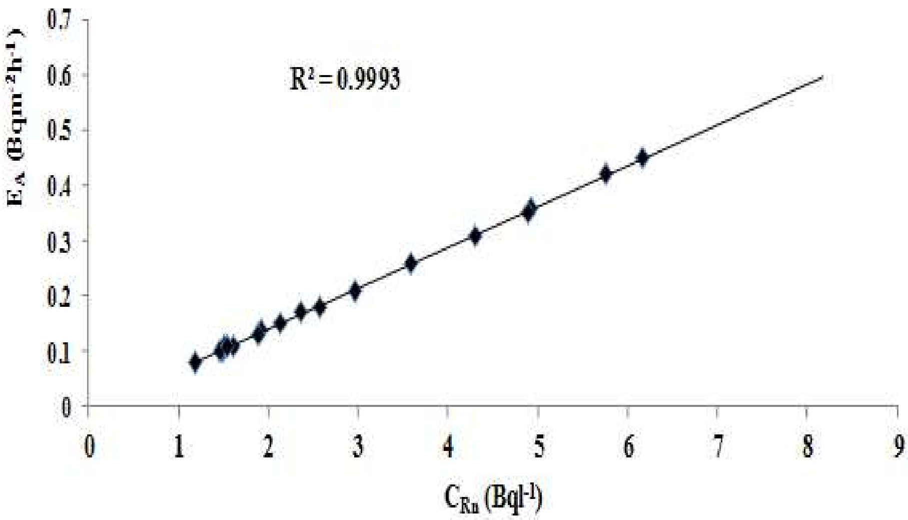

Figure 5: The Correlation relation between Radon Concentration and Radon Exhalation Rate

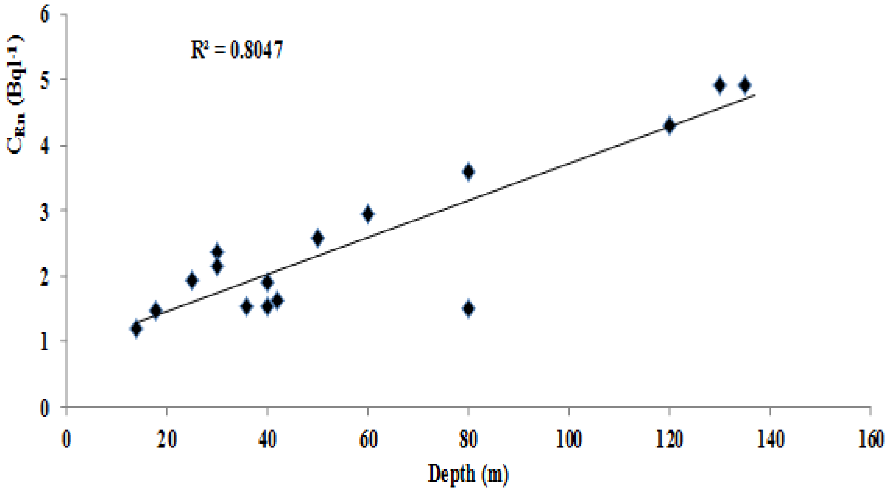

Figure 6: The Relation between the Depth and Radon Concentration

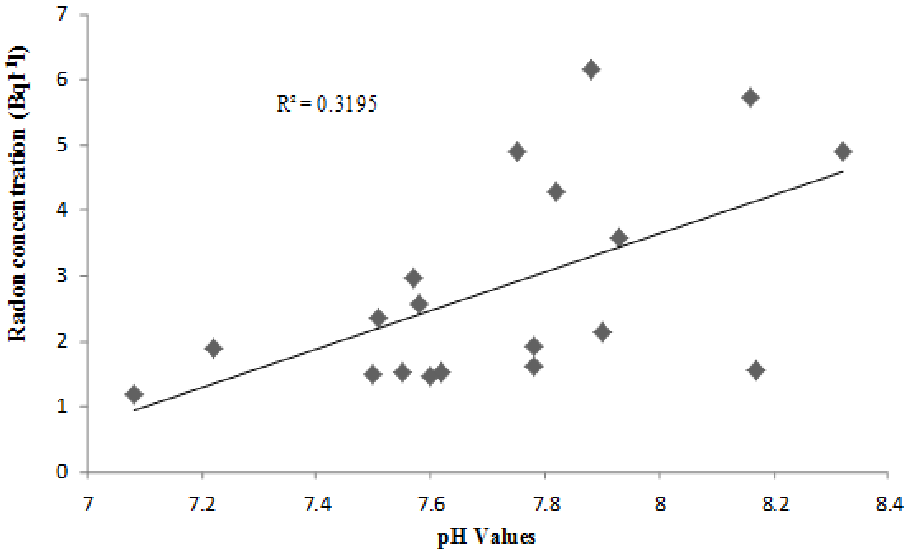

Figure 7: The Relation between pH Values and Radon Concentration

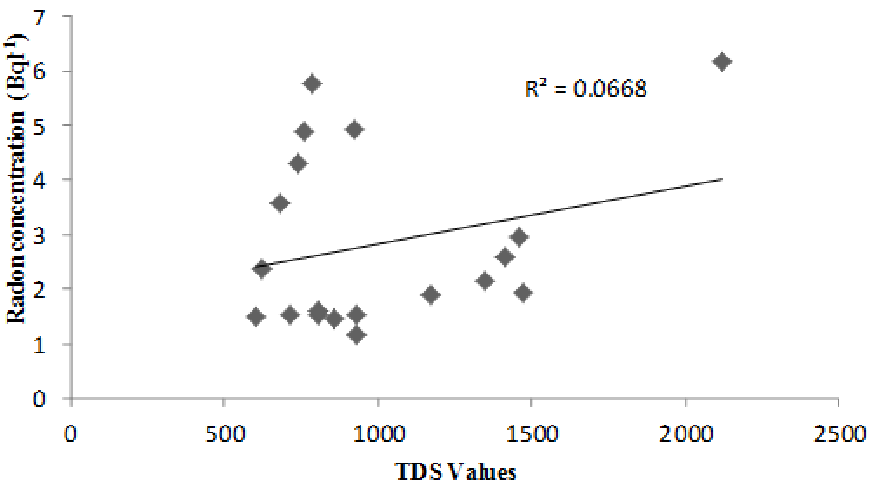

Figure 8: The Relation between TDS and Radon Concentration

Table 2: The comparison between the obtained Experimental Results and the Published Data in different Countries of the World

Country	C_{Rn} (BqL^{-1})	References
Egypt	0.14 - 0.96	[5]
Libya	3.46 ±1.76	[18]
Sudan	59.20	[19]
Saudi Arabia	3.06 - 15.02	[20]
Jordan	2.70 - 6.30	[21]
Kuwait	0.74	[22]
Lebanon	2.50	[23]
Iraq	26.37	[24]
Iraq	1.18 - 7.58	[25]
Iraq	0.30 ± 0.10	[26]
Iraq	0.024 - 0.23	[27]
Iran	30.20 - 18.40	[28]
Iran	5.32	[29]
India	0.58 – 3.40	[30]
India	9.30 ± 1.45	[31]
Egypt	1.18 – 6.17	The present work

CONCLUSIONS

This study has as basic objectives the radioactivity control of the water samples, which available for human intake and some well water. It is important to determine background radiation levels and estimation of radon exposure in order to evaluate the health hazards. Radon concentrations were measured for collecting samples from 19 locations of Graduate's Villages at western Nile Delta, Egypt; using passive technique. The values of radon concentration varied from 1.18- 6.17 Bql^{-1}. The results of the present work indicate that the area under investigation has a different ratio of radon concentration. Radon concentration was varied from region to another due to many reasons, like the nature of the soil of the studied area, chemical composition and the depth of wells. Radon concentrations in water depend much on source of radon emanation which may be as a result of natural processes, industrial or agricultural activities and increase in human activities in the area where the wells are located. The values of radon concentration are lower than the recommended level of [1] which is equal 10 Bql^{-1} and EPA, which is equal 11 Bql^{-1}[32]. The value of radon concentrations obtained in groundwater was compared with those reported by the other investigators in different parts of the world are summarized in Table 2. The results are in a good agreement with some values previously reported by different authors in different countries. From the obtained results we can conclude that, the groundwater is relatively shallow in depth and very sensitive to surface activities such as rate of water withdrawing, irrigation canals and chemical fertilizers. It is recommended to use this groundwater carefully without depending totally on it. Also the studied area in the normal radiation level and the obtained data may provide information about the background level for the area. Also used as a guideline in this region for future measurement and assessment of possible radiological risks to human health.

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